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Abstract: Companies should be conscious of optimization of their production and distribution channels for their products. Our purpose is to maximize the profit of a company which deals with such problems. A linear programming model has been implemented for the distribution system to provide optimal operating supply routes. The model simply considers a company with two textile factories manufacturing five identical products in two different areas ("Area" means both market and local suppliers). Sensitivity analysis has been used to improve the earnings of the company and to determine whether the company could handle economic changes.

TRADE BETWEEN AN AGRICULTURAL AND AN INDUSTRIAL REGION IN TEXTILE INDUSTRY

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I.ABSTRACT

The companies should be conscious of optimization of their production and distribution for their products. The purpose of our project is to maximize the profit of a company which deals with such problems. A linear programming model has been implemented for the distribution system to provide optimal operating supply routes. Our model simply considers a company with two textile factories manufacturing five identical products in two different areas ("Area" means both market and local suppliers). The sensitivity analysis has been used to improve the earnings of the company and to see if the company was able to handle economic changes.

II.INTRODUCTION

The present project is a simulation of the exchanges between two regions, to optimize the profit of a company which has interests in both of them. This simulation is developed through four different steps. The first one has defined the specifications of the two regions. The second has integrated those data in a linear programming model. The third has given the solution of the problem and the fourth has studied the results to improve and check the availability of the model.

The exchanges in the model occur at two different levels:

-between suppliers and factories

-between factories and customers.

Not only the intraregion but also the interregion exchange takes place between the regions. They are affected by different economic and industrial factors which will be discussed in the model The effects of those factors will take place in the sensitivity analysis. Then, these findings will be supported in the conclusion and recommendations section.

III.PROBLEM DEFINITION

A.THE COMPANY

The firm which has been studied, represents a medium sized textile company which manufactures five types of cloth. Those are the most commonly used products in the textile industry. Three kinds of fiber constitute them, wool as a natural fiber, with polyacrilic and polyamid as two artificial fibers. The percentages of the different fibers are fixed and well measured for all the finished goods.

The company purchases those raw materials from two suppliers, one for each region. Their prices are directly related to the level of production but not to the quantity purchased.

The finished goods are manufactured in two different plants. For both of the plants, two kinds of production costs incur, a fixed cost and a proportional cost which is related to the outputs of the factory. The products are sold to two customers, one for each region. Those customers can be considered as retailers. They determine their prices directly with the level of the demand in their markets.

The input of each factory can come from both suppliers as the outputs can be sold to both retailers, but the charges of transportation are paid by the company. Those costs are proportional to the weight transported and don't depend on the product transported (no difference between raw materials and finished goods). The charge is the same in both ways (from region 1 to region 2 and from region 2 to region 1) and it is equal to zero for interregional transportation (short distances).

B.THE REGIONS

As it could be induced, each region is considered from three points of view:

-a place of production for raw materials

-a place of production for finished goods

-a market for the manufactured products.

The two regions considered are different in terms of economic conditions. The first one is more likely an agricultural region and the second is typically an industrial one, but all of them are the spatial concentration of a retailer, a supplier and a factor. That's why intraregional transportation costs are ignored.

In terms of supply of raw materials, the agricultural region has a high wool, and a low polyacrilic and polyamid production. As contrary, the industrial region has low production of wool , and high production of those artificial fibers.

In terms of the characteristics of the factories, the agricultural region has a low financial capability and low manufacturing capacity. As contrary, the industrial region has a higher capacity and financial capability.

In terms of the market demand within the regions, the agricultural one has a small market, where the people are more concerned with the low prices rather than the quality. On the other hand, the industrial region has a bigger market where the quality is important in the purchase of an item and the prices are high.

In terms of the transportation between the regions, the same amount of money is charged for both raw material and finished goods. But the limitation of transportation differs from one region to the other.

So the objective function is :

$$\text{maximize } z = \sum_k \sum_l \sum_m PFGlm * QFGklm \quad \text{(sales)}$$

$$- \sum_i \sum_j \sum_k PRMij * QRMijk \quad \text{(purchase of raw materials)}$$

$$- \sum_i \sum_j \sum_k TRMik * QRMijk \quad \text{(transp. of raw materials)}$$

$$- \sum_k \sum_l \sum_m TFGkm * QFGklm \quad \text{(transp. of finished goods)}$$

$$- \sum_k \sum_l \sum_m CFGkl * QFGklm \quad \text{(production costs)}$$

$$- \sum_k FCk$$

In this simple model, TRMik=TFGkm and also

if i=k TRMik=0 and if i<>k TRMik=C (constant)

The fixed costs has not been considered because they are constant and don't change the maximization.

C. THE CONSTRAINTS

i. Production constraints

The regions can provide the factories with more than they have produced:

$$\sum_k QRMijk <= SPij$$

SPij is the maximum production of raw materials j from supplier i.

6.Transport limitation constraints

The company is using trucks in transportation which have a limited capacity. The limitation is the same for both of the regions. But, with finished goods, this limitation is harder to bear because of the packaging:

$$\sum_{J} QRMijk <= WRM$$

$$\sum_{l} QFGklm <= WFG$$

WRM is the capacity of transport for raw materials,

WFG is the capacity of transport for finished goods.

V.DATA

For this simple model, the data have been provided by people with experience in textile industry, marketing and transportation. For a more general model, the use of a database through a matrix generator program would be necessary.

All the data are given in appendices (Appendix A). They included all the prices, costs, productions and capacities defined in the objective function and the constraints.

VI.RESULTS

The numeric application of the model is as follows:

```
MAX 21.0 QFG111 + 21  QFG211 + 6.7 QFG121 + 6.7 QFG221
  + 4.8 QFG131 + 4.8 QFG231 + 8.8 QFG141 + 8.8 QFG241
  + 3.0 QFG151 + 3.0 QFG251 + 23  QFG112 + 23  QFG212
  + 7.4 QFG122 + 7.4 QFG222 + 5.3 QFG132 + 5.3 QFG232
  + 9.7 QFG142 + 9.7 QFG242 + 3.3 QFG152 + 3.3 QFG252
  - 7.7 QRM111 - 7.5 QRM211 - 1.5 QRM121 - 1.3 QRM221
  - 1.0 QRM131 - 0.9 QRM231 - 7.7 QRM112 - 7.5 QRM212
  - 1.5 QRM122 - 1.3 QRM222 - 1.0 QRM132 - 0.9 QRM232
  - 0.3 QRM112 - 0.3 QRM122 - 0.3 QRM132 - 0.3 QRM211
  - 0.3 QRM221 - 0.3 QRM231 - 0.3 QFG112 - 0.3 QFG122
  - 0.3 QFG132 - 0.3 QFG142 - 0.3 QFG152 - 0.3 QFG211
  - 0.3 QFG221 - 0.3 QFG231 - 0.3 QFG241 - 0.3 QFG251
  - 7.4 QFG111 - 7.4 QFG112 - 2.3 QFG121 - 2.3 QFG122
  - 1.7 QFG131 - 1.7 QFG132 - 3.0 QFG141 - 3.0 QFG142
  - 1.1 QFG151 - 1.1 QFG152 - 6.3 QFG211 - 6.3 QFG212
  - 2.0 QFG221 - 2.0 QFG222 - 1.4 QFG231 - 1.4 QFG232
  - 2.6 QFG241 - 2.6 QFG242 - 0.9 QFG251 - 0.9 QFG252

SUBJECT TO

1.   QRM111 + QRM112 < 300
2.   QRM121 + QRM122 < 100
3.   QRM131 + QRM132 < 100
4.   QRM211 + QRM212 < 150
5.   QRM221 + QRM222 < 300
6.   QRM231 + QRM232 < 150
7.   7.0 QRM111 + 8.1 QRM211 + 1.5 QRM121 + 1.6 QRM221 +
     0.3 QRM211 + 0.3 QRM221 + 0.3 QRM231 + 0.3 QFG112 +
     0.3 QFG142 + 0.3 QFG152 + 0.3 QFG122 + 0.3 QFG132 +
     1.0 QRM131 + 1.2 QRM231 < 1000
8.   0.3 QRM112 + 0.3 QRM122 + 0.3 QRM132 + 0.3 QFG211  +
     7.3 QRM112 + 7.8 QRM212 + 1.8 QRM122 + 1.3 QRM222  +
     0.3 QFG241 + 0.3 QFG251 +  0.3 QFG221 + 0.3 QFG231 +
     1.0 QRM132 + 0.9 QRM232 < 2000
9.   QFG111 + QFG112 < 50
10.  QFG121 + QFG122 < 80
11.  QFG131 + QFG132 < 90
12.  QFG141 + QFG142 < 65
13.  QFG151 + QFG152 < 130
14.  QFG211 + QFG212 < 120
15.  QFG221 + QFG222 < 190
16.  QFG231 + QFG232 < 175
17.  QFG241 + QFG242 < 140
18.  QFG251 + QFG252 < 250
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19.   QFG111 + QFG211 = 25
20.   QFG121 + QFG221 = 50
21.   QFG131 + QFG231 = 45
22.   QFG141 + QFG241 = 40
23.   QFG151 + QFG251 = 75
24.   QFG112 + QFG212 = 80
25.   QFG122 + QFG222 = 85
26.   QFG132 + QFG232 = 140
27.   QFG142 + QFG242 = 70
28.   QFG152 + QFG252 = 80
29.   -1  QRM111 - 1.0 QRM211 + 1.0 QFG111 + 1.0 QFG112 +
      0.4 QFG121 + 0.4 QFG122 + 0.3 QFG131 + 0.3 QFG132 +
      0.5 QFG141 + 0.5 QFG142 = 0
30.   -1  QRM121 - 1.0 QRM221 + 0.4 QFG121 + 0.4 QFG122 +
      0.5 QFG131 + 0.5 QFG132 + 0.5 QFG141 + 0.5 QFG142 +
      1.0 QFG151 + 1.0 QFG152 = 0
31.   -1  QRM131 - 1.0 QRM231 + 0.2 QFG121 + 0.2 QFG122 +
      0.2 QFG131 + 0.2 QFG132 = 0
32.   -1  QRM112 - 1.0 QRM212 + 1.0 QFG211 + 1.0 QFG212 +
      0.4 QFG221 + 0.4 QFG222 + 0.3 QFG231 + 0.3 QFG232 +
      0.5 QFG241 + 0.5 QFG242 = 0
33.   -1  QRM122 - 1.0 QRM222 + 0.4 QFG221 + 0.4 QFG222 +
      0.5 QFG231 + 0.5 QFG232 + 0.5 QFG241 + 0.5 QFG242 +
      1.0 QFG251 + 1.0 QFG252 = 0
34.   -1  QRM132 - 1.0 QRM232 + 0.2 QFG221 + 0.2 QFG222 +
      0.2 QFG231 + 0.2 QFG232 = 0
35.   QRM111 + QRM112 + QRM121 +
      QRM122 + QRM131 + QRM132 < 500
36.   QRM212 + QRM211 + QRM222 +
      QRM221 + QRM232 + QRM231 < 500
37.   QFG111 + QFG121 + QFG131 + QFG141 + QFG151 +
      QFG112 + QFG122 + QFG132 + QFG142 + QFG152 < 400
38.   QFG212 + QFG222 + QFG232 + QFG242 + QFG252 +
      QFG211 + QFG221 + QFG231 + QFG241 + QFG251 < 400
      END
```

The results associated with this formulation are put in Appendix B at the end of the project.

The company's profit is maximized and resulted as;

Z = $1,456,734.00 (without fixed costs)

As it is indicated in the printout, some of the raw materials and finished goods are flowing from one region to another. This is the principal point of study to have a general understanding of this economic model.

QRM221 = 62.043480 tons/year

QRM112 = 21.560870 tons/year

QFG211 = 0.086961 tons/year

QFG122 = 30.000000 tons/year

QFG132 = 25.086960 tons/year

For raw materials, the flows try to balance the production between the regions. They occur from a region with a high level of production to the one with a low level. Wool goes from the agricultural to the industrial region and it is the contrary for polyacrilic. Polyamid, in sufficient quantity in both regions, is not exchanged.

For manufactured products, it seems that the factory 1 has a sufficient capacity to meet the demand of its market and the rest of the production is sold on the other market with higher prices. Products 2 and 3 are exported to region 2. Factory 2 works to complete the demand on those products and also fulfills the demand for the rest.

VII.SENSITIVITY ANALYSIS

A.SLACKS AND BINDING CONSTRAINTS

The binding constraints are the limitations of the profit in the solution. Their study indicates on which factors the company can act to improve its profit. The ranking of all the shadow prices, associated with each binding constraint, permits to see the most profitable change in the resource allocation.

In the solution, there are five different binding constraints in this order:

constraint 38 on transportation for region 2
constraint 4 on wool supply in region 2
constraint 2 on polyacrylic supply in region 1
constraint 7 on cash availability in factory 1
constraint 10 on production capacity of product 2 in factory 1.

To improve its profit, the company can increase its capacity in those resources. For example, it can find new supplier in wool and polyacrylic, buy a machine or a truck, or borrow money. The righthand side ranges give the limit to those changes if the company wants to maintain its production at the same level. The limit and the increase in the profit are as follows for the previous constraints:

constraint 38: 0.08 tons/year and $69 !!!

constraint 4: 21.6 tons/year and $10780

constraint 2: 0.75 tons/year and $91 !!!

constraint 7: $300 and $15 !!!

constraint 10: 29.4 tons/year and $870!!!

The only interesting corrective action for the company is to find a supplier of wool in region 2. The price proposed by this supplier will tell if the action is profitable.

The slacks indicate for which resource the company can lower its capacity. Their analysis in the present case shows that the company can decrease the cash allocated to factory 2 and can sell some of its machines, especially those to produce the finished good 5 in factory 1 and the finished goods 2 and 5 in factory 2 (big slacks).

An interesting action for the company is to transfer some of its resources from one region to another. This will be studied in a paragraph below.

B. THE COEFFICIENTS OF THE OBJECTIVE FUNCTION

The coefficients of the objective function are two types. For the finished goods, they represent the profit of the company on a particular product. For the raw materials, it is the cost of a fiber, including the cost of transportation. They are not easy to study, because many factors influence them (price, transportation and type of production,...). But it is interesting to remark that for many of them only a change of 1% can modify the general production (QFG111, QFG211, QFG122, QFG222, QFG132, QFG232). This indicates that they should be very well evaluated, especially for the finished goods given above.

C. PARAMETRIC PROGRAMMING

1. Transfer of internal resources

The cheapest thing to do is to transfer capital from one factory to the other (appendix C1), but it has been shown before that the increase in the profit is tiny. The solution almost didn't change. Now QFG211=0 and before it was 87Kg. From the manager's point of view, there is no need in giving more cash to factory 1. Even if he doesn't import 87kg of wool, his production is practically optimized.

Associated with the cash available, the economists has defined a measure of industrial performance, the return of investment (ROI). For this company, even without considering the fixed costs, this ratio is about 0.5 (1457/3000=0.485), which is very low. This company is not in good shape (it really needs to use LP!).

Anxother possible transfer of resources is the transfer of machines from one factory to another. But it has been shown before that this is not interesting. So the last transfer to be considered is the switching of trucks from the transportation of raw materials to the transportation of finished goods. Each truck can transport 10 tons of raw materials or 8 tons of finished goods. The trucks are going both ways which explains the same limitation for going from region 1 to 2 and from region 2 to 1.

The optimal switching of trucks is proposed in Appendix C2. The solution shows that 7 trucks could transport finished goods instead of raw materials. The profit has increased by $27000. The way the factories are operating has completely changed. Now, the region 1 produces finished goods for its own market, but exports raw materials as much as the capacity of transportation allows. Still the factory 2 works to meet the demand on its market.

2. Economic changes

This part is to show how the company will respond to usual economic changes such as inflation and increase of market demand. To simplify the economic reality, the prices will remain the same even in case of a variation of the market demand.

The success of a company depends mainly on its capability to adopt itself to the market demand. In the model, if the demand on market 2 increases by 10%, the following remarks can be made (Appendix C3): for raw materials, the solution doesn't change, but for finished goods, the region 1 has stopped its production of product 1 and started to produce more of product 5 for export; the region 2 has to answer the demand of product 1 in market 1 and produces for its intraregion consumption. The profit has increased by $75000 (+5.1%).

On the contrary, if the same market demand decreases by 10% (Appendix C4), the profit decreases by $88000 (-6.0%). The solution remains the same except that the factory 1 doesn't export the product 3 anymore (lack of polyacrylic).

An increase by 10% in market 1 (Appendix C5) gives the same effect as before with the market 2. But, since this market is smaller, the profit increase is only $18000 (+1.2%).

The transportation cost doesn't affect the solution, but affects the profit. For example, a variation of +/-10% (Appendices C6 & C7) changes the profit by $4000 (+0.2%) and by $5000 (-0.3%).

The solution changes with an inflation of 10% (Appendix C8). The profit of the company increases by $329000 (+22.6%). If the inflation is considered in the calculation of the profit, the augmentation remains very high (+10.3%). The changes in the basic variables occur in the same way as in an increase of the market demand. If the inflation in the country is well forecasted, the company can adapt its production and take advantage of this situation.

3.Extreme modelization

For the model, the regions are not completely agricultural or industrial. They still produce some artificial fibers and some wool. But it is possible to consider an extreme situation where one region produces only wool and the other one only polyacrylic and polyamid (Appendix C9). In this case, the profit drops by $95000 (-6.5%). This shows that a region has to keep varied production of raw materials to maximize its profit. The solution changes : factory 1 starts to export product 5 instead of product 3.

VIII. CONCLUSIONS

Even though it is simple, this model works well to describe the flows between the two regions. All the results obtained are in harmony with the economic rules. It could certainly help a company to plan its production.

The model could be improved in different ways. The prices for each movement could be different; the variation of the market demand could be considered and an supplier with a market could represent the relations with outside. But to simulate the trade between two countries, a multiple objective function model should be used to defend the rights of both sides and for example, constraints like trade barriers could be implemented.